The Impact of Biofuel Production on Crop Production in the Southern Plains

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Southern Agriculture Economics Association Conference

February 3-6, 2007

Mobile, Alabama

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Abstract

The objective of the study is to determine how grain-based ethanol, cellulosic-based ethanol, and biodiesel production could influence cropping patterns in the Southern Plains. The study analyzes current and potential biofuel crop production and projects cropping changes at various biofuel prices.

Introduction and Background

In today's society the constant concern of high petroleum prices, environmental conditions, unstable supply, and geopolitical issues are all attributable to biofuel production being one of the most controversial and popular topics on the political agenda. Policy factors and a number of other incentives at the state level have also attributed to the interest in biofuel production. These factors have risen at a time of significantly low agricultural commodity prices, and have led to a relatively quick expansion in the interest and production of biofuels (Ugarte et. al.).

Ethanol production has already had major impacts in the grain belt. Ethanol demand for corn has influenced corn basis levels, the demand for storage infrastructure and impacted unit-train loading and river market facilities. Biofuel production is currently expanding into the Southern Plains, a typically grain deficit region. The region's advantages in terms of lower natural gas prices (an important input in ethanol production), distance to ethanol markets and demand for distillers grain by-products appear to offset the rail transportation cost for the grain inputs. Ethanol project organizers in the Southern Plains also anticipate increased production of corn and grain sorghum and/or shifts of winter wheat production into winter barley a potential ethanol feedstock.

There is also recent interest in biodiesel production in the Southern Plains region. New varieties of winter canola are being developed, but have not yet proven. Winter wheat producers are adopting winter canola as a rotational crop to achieve diversification and for the agronomic advantages that can be gained from rotating between grass and broadleaf crops. Canola adoption would be expected to increase dramatically if the crushing and biodiesel production infrastructure is developed. Locating a biodiesel production facility in the Southern Plains region would rationally be expected to increase the demand for both, winter canola production and summer oilseed crops such as soybeans, yet another major agriculture commodity used to produce biodiesel.

There is also the possibility of cellulosic – based ethanol that comes from feedstocks such as switchgrass, corn stover, wheat straw and wood products residues that could potentially lead to an even greater impact on the agricultural industry (Epplin). Researchers in the Department of Biosystems and Engineering at Oklahoma State University have developed pilot-scale equipment for the production of ethanol from switchgrass. Potential conversions of 75 gallons or higher from each ton of switchgrass coupled with expected switchgrass yields of 4-6 tons/acre (estimated to be equivalent to the yield of pasture hay) have led to excitement over the future role of dedicated biofuel crops in the regions agriculture. President George Bush mentioned switchgrass in his 2006 State of the Union speech. A September 8 article appearing in the New York Times included the statement "You could turn Oklahoma into an OPEC member by converting all of its farmland into switchgrass."

Research and development is ongoing in an attempt to develop economically competitive methods to produce ethanol from cellulose. However, as of this writing no economically competitive commercial size facility exists in the United States (Ugarte et. al.). Technological breakthroughs have not occurred at the rate anticipated. Several competing conversion technologies that would enable use of cellulosic biomass for biorefinery feedstock are under development. Examples include gasification, pyrolysis, liquefaction, fermentation, and anaerobic digestion (Epplin). A number of challenges must be overcome if cellulosic ethanol is to become an economically competitive alternative to corn-ethanol and eventually to gasoline.

If and when an economically competitive bioconversion system is developed, it is anticipated that the agricultural community will be actively engaged in the production, harvest, storage, and transportation of feedstock to biorefineries. Relative to corn grain, cellulosic material such as switchgrass is bulky and difficult to transport. Ethanol plants may post a competitive price and corn grain will be delivered by the existing marketing system. The infrastructure for production, harvest, storage, transportation, and price risk management of corn grain is well developed. Unlike corn grain, a well-developed harvesting and transportation system does not exist for cellulosic biomass such as switchgrass and crop residues.

This study provides an important first step in identifying and quantifying the Southern Plains' potential biofuel industry. It should be noted that there are inherent uncertainties in projecting the Southern Plains' potential in cellulosic ethanol. These include the cost and efficiency in converting cellulosic material into ethanol and the adaptability and yields of dedicated energy crops such as switchgrass. This study projects when producers would have an economic incentive to convert their current crops into biofuel feedstock crops. The study did not attempt to model the likelihood or time path of such conversions. A significant investment in infrastructure will also be required before Oklahoma and the Southern Plains region can realize the potential identified in this report. Full development of a grain-based biofuel industry could require an investment of up to $1 billion while full development of a celluloic based industry could require $10 billion or more infrastructure investment.

The biofuel industry represents a potential opportunity for the Southern Plains. However, it should be emphasized that all land in farms is currently in use. A biofuels industry would bid resources from current use with possible negative impacts on some agricultural sectors. It should also be noted that this writing is a broad overview of the research conducted by a multidisciplinary team at Oklahoma State University, for more information and specific results please refer to the publication "Potential for Production of Biofuel Feedstocks in Oklahoma," written by Phil Kenkel, Chad Godsey’ Francis Epplin’ Mark Gregory, Rodney Holcomb, and Ray Huhnke.

Objectives

The objective of this study is to determine how grain-based ethanol, cellulosic-based ethanol and biodiesel production could influence cropping patterns in Oklahoma and the Southern Plains. The amount of potential biofuel feedstocks that are currently produced in the Southern Plains region on a county – by – county basis must be determined, as well as the amount of potential cellulosic-based ethanol feedstocks that are currently produced on the same basis. Then it must be estimated how sensitive the adoption of biofuel crops are, relative to various price levels. The final objective is to determine which crops convert into potential biofuel producing crops at what price level.

Using agricultural crops and other plant and plant-derived material to produce transportation fuel could reduce the needs for imported oil while benefiting the agricultural and rural economies. A multidisciplinary team at Oklahoma State University investigated Oklahoma’s current production of biofuel crops and the state’s potential for increased biofuel production. A detailed model was developed to compare the net returns of all existing crops to that of biofuel crops to determine the potential for increased biofuel crop production.

Data and Methods

A mathematical programming model was used to project the potential impacts of biofuel production on the Southern Plains crop production. The model compares the revenues of existing crops by county, to the potential revenues earned by converting to alternative biofuel crops. County level price and yield data and university budget production cost estimates were used to reflect revenues and costs for existing crops. The model demonstrates the percentage of crop acres converted to grain-based biofuels at various price levels, but one must keep in mind that there is gradual adoption to any new technology or market opportunity (hybrid corn took 10 years). Additional activities reflecting grain-based ethanol production and biodiesel production were also developed. The net revenues of the biofuel production activities reflected the fixed and variable production costs plus a 15% return on equity. Biofuel revenues in excess of these costs were assumed to accrue to the feedstock producer. This provides an upper limit on the possible biofuel crop adoption. An additional scenario representing cellulosic – based ethanol production using switchgrass feedstock was also developed. County level estimates of switchgrass yield and production cost were estimated based on existing pasture hay crop production data. Cellulosic ethanol production from corn stover, wheat straw and switchgrass production on Conservation Reserve Program (CRP) acres was also modeled. The programming model was used to project the potential shift in crop acres to biofuel crops at various biofuel prices.

CRP Land as Potential Biofuel Crop Production

Land currently enrolled in the CRP is a potential land resource for the production of biofuel feedstocks. The CRP is a voluntary program which offered financial incentives to private landowners to protect highly erodible and environmentally sensitive cropland by planting trees, grass, and other long-term cover (USDA). Landowners signed 10-15 year contracts with the USDA, agreeing to take the land out of production for the length of the contract. Farmers are paid for the lost production on the CRP acres. The average CRP rental rate for the Southern Plains is approximately $35 per acre per year. The majority of the CRP acres are located in the Panhandle and western part of the state (Figure 1) and perennial grasses grow on most of these acres.

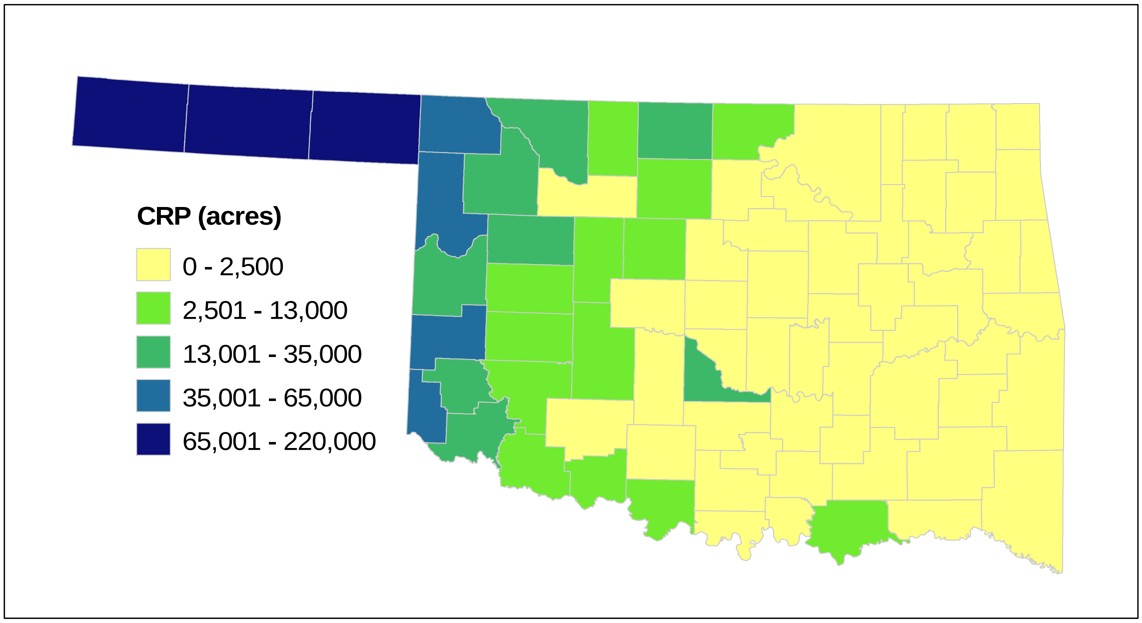


Figure 1. Distribution of CRP Acres in Oklahoma as of 2004.

Most of the CRP land is located in the area of the state that traditionally has the least amount of annual precipitation which limits yield potential. This cropland was enrolled in the CRP because it is "highly erodible" which is correlated with poor soil quality and limited productivity compared with other intensively cropped land. Mapemba has estimated that as currently managed average annual production on Oklahoma's CRP acres is approximately 1.56 dry tons of biomass per acre. With changes in federal policy, these lands have potential to be more intensively managed. However, research would be required to determine yield potential and management systems to maintain the environmental benefits of the CRP. Use of CRP lands to produce biorefinery feedstock would have minimal impacts on other crop and livestock industries due to the fact that it is currently not in any kind of production.

<u>Grain Crops as Potential Biofuel Crop Production</u>

Grains and oilseeds are currently the primary potential biofuel feedstocks. Grain that is produced in the Southern Plains that could be used for ethanol production consists mainly of corn and grain sorghum (Figure 2), while soybeans and cotton are the primary crops currently produced that could be used for producing biodiesel (Figure 3). Average corn and grain sorghum yields from 2001 to 2005 were determined and used to estimate potential for biofuel production (NASS, 2006). As was stated earlier in the writing, a conversion factor of 2.8 gallons of ethanol per bushel of grain was used for both corn and grain sorghum. For estimating biodiesel production, an oil content of 20%, 38%, and 44% was used for soybeans, winter canola, and peanuts, respectively, with an extraction efficiency factor of 85%.

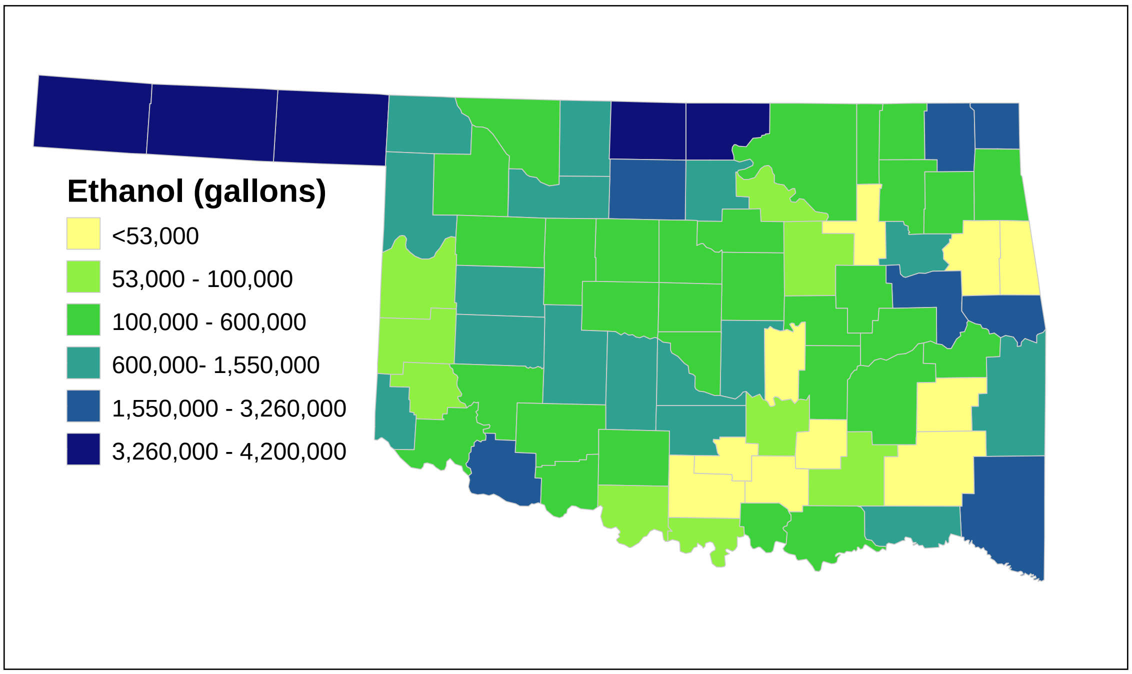
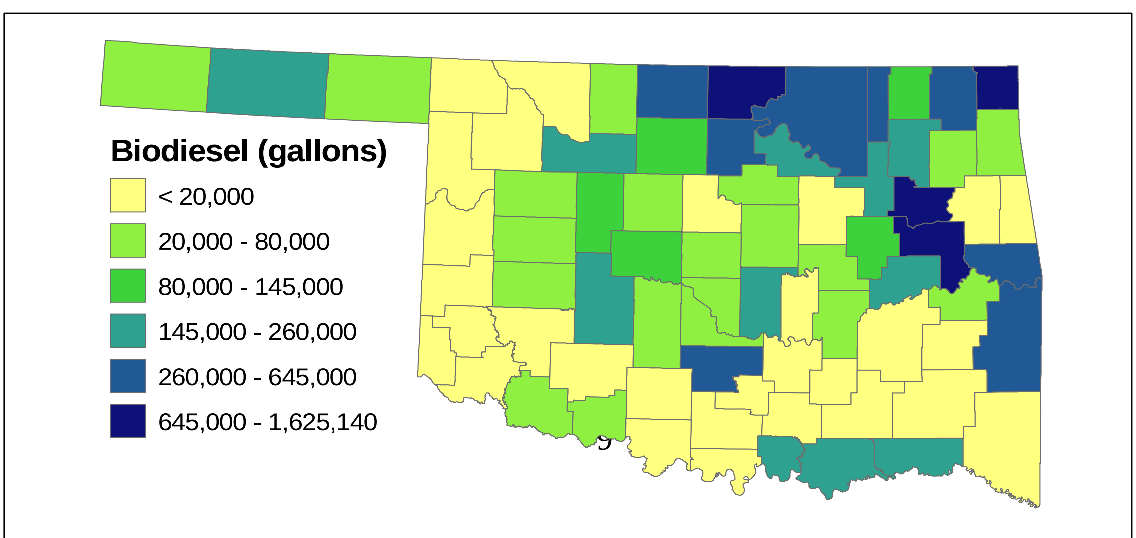


Figure 2. Distribution of Corn and Grain Sorghum that could be Used To Produce Ethanol rather than to Feed Livestock.
(Potential Ethanol yield based upon corn and grain sorghum average grain production from 2001-2005).



Feedstocks.

Wheat production dominates crop acreage in the western part of the state (Figure 4). Winter wheat production is widespread throughout the western region and into the panhandle. Growers in this region often use winter wheat for fall-winter forage for cattle. Winter wheat is well suited for this region due to the growth habits of the crop. It grows during a time of the year that growing conditions are the least harsh. It will most likely take a relatively high ethanol or biodiesel price level to convert winter wheat into barley for ethanol production or canola for biodiesel production.

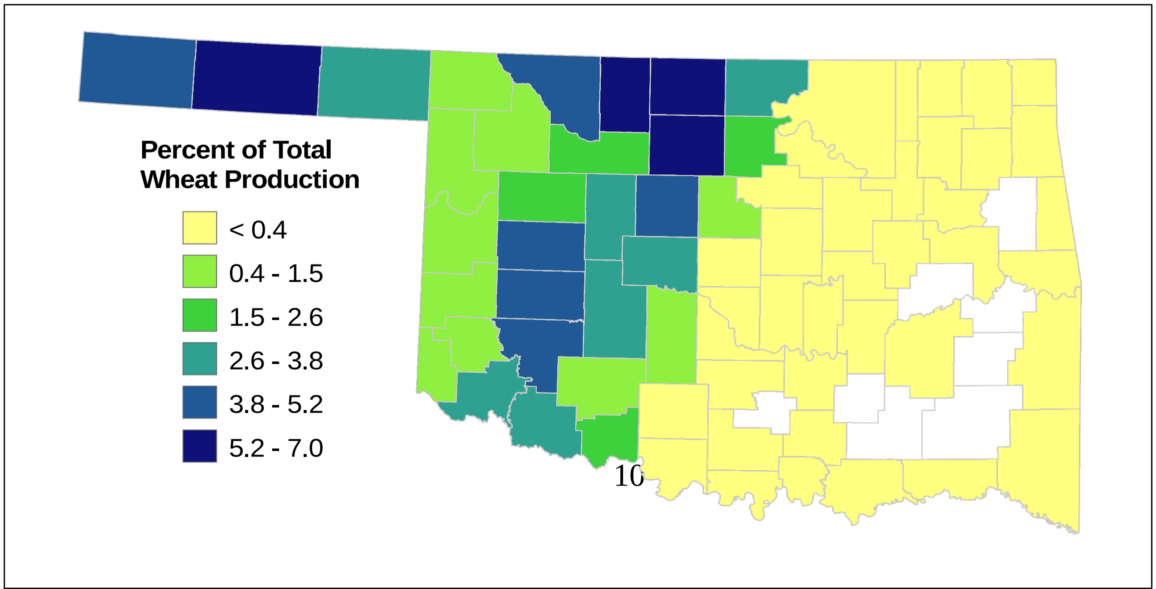


Figure 4. Percent of total Oklahoma Wheat Production by County.
(Non-shaded areas did not harvest any wheat acres in 2005).

If price levels were significant, farmers would have some potential incentive to change current cropping patterns and to increase production of biofuel feedstocks in the state. Producers could convert acreage to increase production of existing ethanol feedstock crops (corn and grain sorghum) and/or existing biodiesel feedstock crop (soybeans and cotton). In addition to the currently grown feedstocks, a variety of other crops are suitable for production in the Southern Plains that have potential as feedstocks. Crops that may have potential but are not grown or grown on a large scale in the state include hull-less barley and sunflower (two ethanol feedstocks), as well as winter canola, peanuts, and numerous other oilseed crops (biodiesel feedstocks).

In general, summer crops such as corn, grain sorghum, cotton, alfalfa, peanuts and oats are grown in areas of the state with higher precipitation patterns and/or irrigation capacity. Winter crops such as hard red winter wheat and rye are grown in areas which typically receive lower amounts of precipitation during the summer months. This dichotomy is not complete as some land can be transitioned between winter and summer cropping patterns. Table 1 provides a summary of the major alternative biofuel crops for the major crops produced in Oklahoma.

Table 1. Alternative Biofuel Crops for Oklahoma

Crop	Harvested Acres	Potential Alternative Crop: Ethanol	Potential Alternative Crop: Biodiesel
Wheat	4,000,000	Hulless Barley	Winter canola

Hay	2,920,000	Corn or sorghum	Soybeans, various oilseeds
Corn	290,000	(current ethanol feedstock)	Soybeans, various oilseeds
Grain Sorghum	270,000	(current ethanol feedstock)	Soybeans, various oilseeds
Soybeans	305,000	Corn or sorghum	(current biodiesel feedstock)
Cotton	240,000	Corn or sorghum	Soybeans, various oilseeds
Rye	70,000	Hulless barley	Winter canola
Alfalfa	55,000	Corn or sorghum	Soybeans, various oilseeds
Oats	45,000	Corn or sorghum	Soybeans
Peanuts	35,000	Corn or sorghum	(current biodiesel feedstock)

Results

Current Biofuel Production

The Southern Plains region currently produces grain based ethanol feedstocks equivalent to 112 million gallons of ethanol production and biodiesel feedstocks equivalent to 16 million gallons of biodiesel. Table 2 demonstrates the current possibility of biofuel production. Technologies are also being developed to produce ethanol from cellulosic feedstocks such as corn stover, wheat straw, hay or dedicated energy crops such as switchgrass. If these technologies were available, Oklahoma and the Southern Plains Region's current production of these feedstocks is equivalent to an additional 797 million gallons of ethanol.

Table 2. Current Possibility for Biofuel Production

Crop	Land in Production (acres)	Total Annual Yield (bushels)	Potential Biofuel (gallons)
Corn (ethanol)	200,000	26 Million	75 Million
Sorghum (ethanol)	310,000	13 Million	37 Million
Soybeans (biodiesel)	238,000	9 Million	16 Million

Based on a conversion rate of 2.8 gallons of ethanol per bushel was assumed for the conversion of corn and sorghum and based on a conversion rate of 1.34 gallons of biodiesel from every 60lb. bushel of soybeans. (Those conversions with be further defined later in the writing). All data collected from USDA.

Potential for Biofuel Crop Production

The results indicated that at ethanol prices above $2.00/gallon dry cotton and peanut acreage would shift into feed grain production. Ethanol prices of almost $2.90/gallon were required to shift hard red winter wheat acreage into grain sorghum production. Ethanol prices of over $4.00/gallon were required before hard red winter wheat acres began to shift into winter barley. Total ethanol production at $3.00/gallon was projected at slightly over 200M gallons/year.

While the winter barley/ethanol production was not competitive enough with hard red winter wheat production, the results show that winter wheat acres would shift into canola/biodiesel production at biodiesel prices below $2.00/gallon. Summer crops (cotton, peanuts, corn, grain sorghum and alfalfa) shifted into soybean/biodiesel production only at very high (> $5.00/gallon) biodiesel prices. At $3.00/gallon the results indicated that the shift in wheat acreage would be sufficient to produce almost 350M gallons of biodiesel.

Potential for Production of Cellulosic Feedstocks

As expected the addition of cellulosic ethanol substantially increases the projected potential ethanol. While the production of switchgrass for ethanol on Conservation Reserve Program land is often touted as a future energy solution, the model results indicated that existing cropland would shift into switchgrass at lower ethanol prices than were required to convert conservation reserve land. Wheat acres were projected to begin shifting into cellulosic ethanol prices of slightly over $2.00/gallon which would lead to substantial production (over 1B gallons/year) at $3.00/gallon and higher prices.

All in all, the results from the model indicate that land converts into a biodiesel producing crop at a considerably lower price than converting land into ethanol producing crops. This ultimately suggests that the Southern Plains region may have more potential for a niche market in biodiesel production versus ethanol production. The potential conversion of wheat into canola represents the largest single potential source of biodiesel, yet keep in mind that canola has not been completely proven.

Summary and Conclusion

The results of this research are obviously influenced by a number of factors and assumptions, most notably biofuel conversion rates and crop production cost estimates. With that in mind, they also provide significant insight into the impact of biofuel production on the Southern Plains crop production.

The mathematical programming model demonstrates the impacts of biofuel production on Oklahoma and the Southern Plains region cropping patterns. Grain-based ethanol production, biodiesel production, and cellulosic-based ethanol production were modeled. Currently, the Southern Plains produces grain based feedstocks equivalent to 112 million gallons of ethanol and 16 million gallons of biodiesel. If cellulosic-based ethanol were commercialized the Southern Plains current production of these feedstocks would be capable of an additional 797 million gallons of ethanol. The results indicated potential biofuel crop adoption equivalent to 666 million gallons of ethanol and 338 million gallons of biodiesel at ethanol and biodiesel prices of $2.50/gallon. At $5.00/gallon for ethanol and biodiesel, the potential production for ethanol was 971 million and the biodiesel potential was 1 billion gallons. Again, if cellulosic-based ethanol were commercialized the Southern Plains region would have the potential to increase the ethanol production to 2 billion gallons at an ethanol price of $2.50/gallon and the potential for 2.4 billion gallons at an ethanol price of $5.00/gallon. Even though this study implies that most of the CRP land would be converted to switchgrass for the production of cellulosic ethanol, the biggest impact for the production of cellulosic ethanol would be to convert all wheat acres to switchgrass production.

As a result of energy security concerns alternative energy sources such as mass biofuel production, are becoming highly demanded. Large scale production of biofuel crops will have serious impacts on the agriculture sector in terms of quantities, prices, and production locations. With the results and conclusions derived in this study, it enables farmers, political leaders, and other interested patrons to make knowledgeable decisions about the future and impacts of biofuel production in the Southern Plains.

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